Management Measure 9
Pollution Prevention

A. Management Measure

Implement pollution prevention and education programs to reduce nonpoint source pollutants generated from the following activities:

- The improper storage, use, and disposal of household hazardous chemicals, including automobile fluids, pesticides, paints, solvents, etc.
- Lawn and garden activities, including the improper application and disposal of lawn and garden care products and the disposal of leaves and yard trimmings.
- Turf management on golf courses, parks, and recreational areas.
- Commercial activities, including parking lots, and gas stations.
- Improper disposal of pet wastes.
- Trash accumulation.

B. Management Measure Description and Selection

1. Description

This management measure is intended to prevent or reduce nonpoint source pollutant loadings generated from a variety of activities within urban areas. Everyday activities of citizens, municipal employees, and businesses have the potential to contribute to nonpoint source pollutant loadings. Some of the major sources include improper disposal of household hazardous wastes, lawn and garden activities, turf grass management, operation and maintenance of diesel and gasoline vehicles, illicit discharges to urban runoff conveyances, commercial activities, and pet wastes. Reducing pollutant generation can decrease adverse water quality impacts from these sources.

The practices presented in this management measure are often referred to as source reduction practices. These practices are nonstructural in nature and reduce the amount of pollutants generated, thereby reducing the burden of treatment to maintain water quality. Costs of source control practices are typically associated with programmatic expenses such as signage, outreach materials, workshops, and development and enforcement of ordinances. Source reduction practices can reduce the quantity of runoff and the concentration of pollutants entering runoff treatment facilities, resulting in an overall cost savings from smaller sizes and less maintenance.

a. Household hazardous wastes

Household hazardous wastes can be defined as wastes that display any of the following characteristics: flammable, combustible, toxic, explosive/reactive, or corrosive. Household hazardous wastes can pose long-term threats to human health, wildlife, vegetation, and other environmental resources. Unlike industrial hazardous wastes, not all household hazardous wastes are regulated by federal, state, and local laws. In fact, the federal Resource Conservation and Recovery Act, which regulates other forms of hazardous waste, has a special exemption for household hazardous wastes (Kopel, 1998). The Federal Insecticide, Fungicide, and Rodenticide Act regulates the use and disposal of pesticides, herbicides, and fungicides through labeling.

Studies indicate that Americans generate 1.6 million tons of household hazardous wastes each year (Earth's 911, 2000). The following is a list of common household hazardous wastes that contribute to nonpoint source pollution (MPCA, 2002):

Automotive
- Auto batteries
- Brake fluid
- Carburetor cleaner
- Degreasers
- Fuels
- Oil filters
- Used antifreeze
- Used motor oil

Household items
- Aerosol products
- Button batteries
- Batteries (rechargeable)
- Drain cleaners
- Fluorescent lights
- Mothballs
- Nail polish/remover
- Oven cleaner
- Polish w/solvents
- Spot removers
- Thermometers (Hg)

Lawn & garden
- Bug spray
- Charcoal lighter fluid
- Fertilizer (w/weed killer)
- Insect killer
- Pool chemicals
- Rodent bait
- Weed killer

Home improvement
- Concrete cleaner
- Driveway sealer
- Furniture stripper
- Glue (w/solvents)
- Latex paint
- Oil-based paint
- Paint remover
- Paint thinner
- Roofing tar
- Stain/varnish
- Wood preservatives

The four main avenues for household hazardous wastes to become problem pollutants are through leaks and spills, improper use, improper storage, and improper disposal.

(1) *Leaks and spills*. Leaks from improperly maintained automobiles and lawn equipment or faulty chemical containers can accumulate on roads, driveways, and lawns and be carried by runoff to receiving waterbodies.

(2) *Improper use*. Overapplication of fertilizers and pesticides can lead to chemical accumulation in the soil and grass. These chemicals can leach to ground water or be carried by runoff to surface waters.

(3) *Improper storage*. Earth's 911 (2000) estimates that the average home may accumulate as much as 100 pounds of household hazardous wastes in the garage, basement, and storage closets. Improper storage of chemicals can lead to spills that can contaminate runoff and ground water or can result in dangerous chemical reactions.

(4) *Improper disposal*. It is a common practice for citizens to pour unwanted chemicals, such as detergents, cleansers, or automotive fluids, onto their lawns or driveways or directly down

storm drains. Contrary to popular belief, most storm sewers do not connect to wastewater treatment plants—chemicals disposed of this way could be discharged directly to receiving waterbodies. Additionally, when chemicals are poured down drains connected to a wastewater treatment plant or septic system, the chemicals could interfere with treatment systems by killing the bacteria that metabolize pollutants, causing water discharged from the plants to be contaminated. Ground water is also at risk because runoff can carry these chemicals through the soil to the water table.

(5) *Outdoor car washing*. This activity can result in high loads of nutrients, metals, and hydrocarbons to receiving waters during dry weather conditions when the wash water flows into the storm drain system. According to surveys, 50 to 75 percent of households wash their own cars and 60 percent of those households wash their cars at least once a month (Schueler and Swann, 2000b).

b. Failing septic systems

Approximately one in four American households rely on septic systems to dispose of their wastewater. Septic systems have a failure rate of 5 to 35 percent, depending on soil conditions and other factors. When septic systems fail, the untreated or partially treated wastewater discharges to surface and ground waters. A survey conducted in the Chesapeake Bay watershed found that the average age of septic systems in the area was about 27 years, which is 7 years beyond the design life of an unmaintained system. About half the owners indicated that they had not inspected or cleaned out their system in the last 3 years. (Schueler and Swann, 2000b).

c. Lawn and garden activities

It has been estimated that up to 30 million acres of turf and lawn exist in the United States, which, if classified as a crop, would rank as the fifth largest crop in the country (Roberts and Roberts, 1989). A lush, green front lawn is highly desirable to homeowners. Maintaining this image often requires help from fertilizers, pesticides, and heavy watering. In terms of fertilizer inputs, nutrients typically are applied to lawns at about the same application rates as those used for row crops. Contrary to popular belief, beautifully landscaped yards are achievable without massive quantities of chemicals and water.

The chemical lawn care industry generates $1.5 billion of business each year (Environmental Defense Fund, 2000). The products they apply to lawns—fertilizers, pesticides, and herbicides—can pollute runoff if they are applied improperly to the ground. Fertilizers contain nitrogen and phosphorus, which become pollutants when runoff carries excess fertilizers into lakes and streams. Excessive nutrients stimulate algae growth that may lead to death and decay of aquatic vegetation due to light and oxygen deprivation.

Lawns also require physical maintenance in the form of mowing, raking, and removing weeds, clippings, and branches. Jenkins (1994) estimated that a 1-acre lawn generates nearly 6 tons of grass clippings per year and that yard wastes fill up approximately 10 to 50 percent of the nation's landfills. Alternative practices can be used to reduce the quantity of yard wastes generated by lawns and to reuse or dispose of yard wastes to prolong the capacity of landfills.

d. Commercial activities

Runoff from commercial land uses, such as shopping centers, office parks, and parking lots or garages may contain high hydrocarbon loadings and metal concentrations that are twice those found in the average urban area. These loadings can be attributed to heavy traffic volumes and large areas of impervious surface on which automotive-related pollutants concentrate (refer to Management Measure 7, Bridges and Highways, for a discussion of automobile-related pollutants). Other commercial uses, such as vehicle maintenance, liquids storage, and equipment storage and maintenance, can also introduce pollutants to runoff.

In most communities, gas stations are designated as a commercial land use and are subject to the same controls as shopping centers and office parks. However, gas stations may generate high concentrations of heavy metals, hydrocarbons, and other automobile-related pollutants. Since gas stations have high potential loadings and pollutant profiles similar to those of industrial sites, good housekeeping controls, such as those used on industrial sites, are recommended.

Municipalities can target pollution prevention campaigns to specific commercial activities that are suspected of contributing to nonpoint source pollution. Typically, these campaigns involve an assessment of commercial facilities to identify the types of waste produced. The campaigns also outline methods to reduce the total amount of pollutants generated on-site and methods for appropriately disposing of pollutants. A set of rules and use limitations that a commercial tenant must agree to as a condition of occupying a site can be implemented in commercial covenants, conditions, and restrictions.

e. Pet wastes

When pet waste is not properly disposed of, it can wash into nearby waterbodies or can be carried by runoff into storm drains. Since most urban storm drains do not connect to treatment facilities, but rather drain directly into lakes and streams, untreated animal waste can become a significant source of runoff pollution. As pet waste decays in a waterbody, the degradation process uses oxygen and sometimes releases ammonia. Low oxygen levels and the presence of ammonia, combined with warm temperatures, can be toxic to fish and aquatic life. Pet waste also contains nutrients that promote weed and algae growth. Perhaps most importantly, pet waste carries microbes, such as bacteria, viruses, and parasites, that can pose a health risk to humans and wildlife. Pet waste can be controlled through enforcement of ordinances (e.g., warnings and citations, public education, signage, and providing disposal containers).

f. Trash

Trash and floating debris in waterways have become significant pollutants, especially near urban areas where a large volume of trash can be generated in a concentrated area. Trash contributes to visual pollution and detracts from the aesthetic qualities of the landscape. Boaters have complained that trash and debris clog engine intake valves and propellers, which results in expensive repairs. Finally, municipalities must incur the cost of cleanup efforts to restore water quality.

2. Management Measure Selection

This management measure was selected to identify ways that communities can implement practices that bring about behavioral changes to reduce nonpoint source pollutant loading from

the sources listed in the management measure. Such activities include public education, proper management of maintained landscapes, source reduction, training and runoff control plans for commercial sources, pet waste management activities, and trash control. Communities can select practices that best fit local priorities and funding. It is important for the watershed manager to note that community acceptance is often the major determinant affecting whether education and outreach activities and administrative mechanisms such as certification and training requirements are practical or effective solutions.

C. Management Practices

1. Household Hazardous Wastes

The key to preventing household hazardous wastes from entering receiving waters is to educate the public about the hazards of everyday materials. The practices discussed below are intended to inform the public on proper procedures for handling and disposing of household hazardous wastes to prevent pollution resulting from carelessness or ignorance and to instill a sense of responsibility for their actions and choices as consumers.

a. Promote the use of alternative products

A host of biodegradable cleaners and other less toxic chemicals are commercially available. Such alternative products typically contain chemicals that rapidly break down in soil and water into fewer toxic constituents, or they are reusable or recyclable. These include low-phosphate or phosphate-free detergents and water-based products. Table 6.1 lists several less-toxic alternatives to typical household chemicals.

Table 6.1: Less-toxic alternatives to household chemicals (Tacoma-Pierce County, Washington, Health Department, no date).

Purpose	**Less-toxic alternative**
Air freshener	Simmer cinnamon and cloves
Aluminum spot remover	2 tablespoons cream of tartar + 1 quart hot water
Ants	Red chili powder at point of entry
Bleach	Borax
Brass polish	Worcestershire sauce
Car battery corrosion	Baking soda + water
Chrome polish	Apple cider vinegar Baby oil to polish
Cleaners: general household	Baking soda
Coffee cup stain remover	Moist salt
Coffee pot stain	Vinegar
Copper cleaner	Lemon juice + salt
Decal remover	Soak in white vinegar
Dish detergent: grease cutter	1/2 cup baking soda + usual amount of liquid detergent
Drain cleaner	Plunger followed by 1/2 cup baking soda + 1/2 cup of vinegar + 2 quarts boiling water
Fertilizer	Compost and vermicompost
Fiberglass stain remover	Baking soda paste
Fleas on pets	Gradually add brewers yeast to pet's diet

Table 6.1 (continued).

Purpose	Less-toxic alternative
Flies	Well watered pot of basil
Furniture polish	1 tablespoon lemon oil in 1 pint of mineral oil
Garbage disposal deodorizers	Used lemons
Grease fire	Douse with baking soda
Grease removal	Borax on damp cloth
Handcleaner: paint/grease	Baby oil
Ink spot remover	Cold water + 1 tablespoon cream of tartar + 1 tablespoon lemon juice
Insects on plants	Soapy water on leaves, then rinse
Laundry detergent	Basic soap
Linoleum floor cleaner	1 cup white vinegar + 2 gallons water
Mildew remover	Equal parts of vinegar and salt
Mosquito repellent	Burn citronella candles or citronella oil
Moth repellent	Cedar chips enclosed in cotton sachets
Nematode repellent	Plant marigolds
Oil stain remover	White chalk rubbed into stain before laundering
Oven cleaner	2 tablespoons liquid soap + 2 teaspoons borax + warm water
Paint; oil based/stain/spray	Water-based, non-aerosol paints
Paint brush softener	Hot vinegar
Perspiration spot remover	Baking soda
Pet odor remover	Cider vinegar
Porcelain stain removal	Baking soda
Refrigerator deodorizer	Open box baking soda
Roach repellent	Chopped bay leaves and cucumber skins
Rug/carpet cleaner	Club soda
Rust removal (clothing)	Lemon juice + salt + sunlight
Rusty bolt/nut removal	Carbonated beverage
Scorch mark removal	Grated onion
Scouring powder	Baking soda
Shaving cream	Brush and shaving soap
Shoe polish	Banana peel
Silver polish	1 quart warm water + 1 tablespoon baking soda + piece of aluminum foil + 1 tablespoon salt in glass dish; soak silver, rinse, and dry
Slug and snail repellent	Onion and marigold plants
Spot remover	Club soda, lemon juice, or salt
Stainless steel polish	Mineral oil
Toilet bowl cleaner	Paste of borax + lemon juice
Tub and tile cleaner	1/4 cup baking soda + 1/2 cup white vinegar + warm water
Upholstery spot removal	Club soda
Water mark removal	Toothpaste
Water softener	1/4 cup vinegar
Wine stain removal	Salt
Window cleaner	2 tablespoons vinegar in 1 quart warm water
Wood polish	3 parts olive oil + 1 part white vinegar; almond or olive oil (interior unvarnished wood only)

b. Educate the public on proper storage and disposal of hazardous materials

Watershed managers can produce outreach materials that describe methods that homeowners should follow to store household chemicals in appropriate containers and storage areas to prevent leaks, spills, accidental ingestion, and fire or explosion hazards. Tips can include covering piles of potentially hazardous materials that can come into contact with rainfall or runoff; ensuring that containers for volatile, corrosive, or otherwise harmful chemicals are intact; and clearly labeling all containers with the name of the material and the proper storage and disposal procedures. Pesticides, herbicides, and fungicides are addressed below in Section g.

Citizens should also be encouraged to follow the manufacturer's recommendations for disposal of household chemicals. Many communities across the country have implemented programs to collect and safely dispose of these chemicals, such as providing year-round collection facilities or sponsoring household hazardous waste collection days. Effective outreach programs keep citizens informed about the location and hours of operation of disposal facilities and provide a list of waste products that are accepted.

Recycling of certain household hazardous wastes, especially used oil and batteries, can reduce the amount of hazardous materials that enter a landfill. Many municipalities and automotive service stations provide used oil and antifreeze recycling facilities for "do-it-yourselfers" to encourage environmentally sound chemical management. Outreach materials, such as pamphlets and utility bill inserts, can be developed to inform the public of locations and hours of operation of local recycling facilities.

c. Conduct storm drain stenciling

Storm drain stenciling involves labeling storm drain inlets with painted messages that warn citizens of the environmental hazards of dumping materials into storm drains. Stenciling projects are typically conducted by volunteer groups in cooperation with local authorities. The stenciled messages can be a simple phrase to remind passersby that the storm drains connect to local water bodies and that dumping pollutes those waters. Some specify which waterbody the inlet drains to or name the particular river, lake, or bay. Commonly stenciled messages include "No Dumping—Drains to Water Source," "Drains to River," and "You Dump it, You Drink it. No Waste Here." Communities with a large Spanish-speaking population might wish to develop stencils in both English and Spanish or use a graphic without text.

d. Encourage responsible car washing practices

Schueler and Swann (2000b) summarized results of several surveys of automobile owners and their car-washing behavior. The researchers found that 55 to 70 percent of households wash their own cars, with the remainder taking their cars to commercial car washes. Sixty percent of residents washed their cars at least once a month, and between 70 and 90 percent of residents reported that their car wash water drained directly to the street and presumably into the runoff conveyance system. These results indicate that an appreciable amount of wash water laden with detergents, dirt, and automotive fluids can wash into the storm drain system or directly into receiving waters in urban areas.

It is preferable for citizens to patronize commercial car washing facilities because they are mandated under the regulatory authority of the NPDES program (see Chapter 1) to treat and/or

Getting in Step: A Guide to Effective Outreach in Your Watershed

Getting in Step is a guide published by EPA to provide a summary of useful tools for developing and implementing an effective watershed outreach plan. The manual uses a step-by-step approach to help watershed practitioners address public perceptions, promote management activities, and inform or motivate stakeholders. Getting in Step is divided into three parts, as follows:

- Part I presents the overall framework for developing and implementing an outreach plan. It provides specific information about defining goals and objectives; identifying the target audience; creating, packaging, and distributing the message; and evaluating the outreach plan.
- Part II provides tips and examples for developing and enhancing outreach materials, with emphasis on elements of composition and layout, using artwork and photos, establishing a watershed identity, packaging the watershed message, and estimating costs.
- Part III provides specific tips on working with the news media to gain improved media coverage of water quality issues.

Getting in Step also includes worksheets, graphics for use without permission, and information on additional outreach and education resources. The manual is available for download from *www.epa.gov/owow/watershed/outreach/documents/getnstep.pdf* or by calling Books on Demand at 1-800-521-3042.

reuse wash water. If commercial facilities are not available or if residents prefer to wash their cars themselves, they should be encouraged to wash their cars less often, especially in areas with waterbodies sensitive to nutrient enrichment. Another practice to reduce the impact of car washing on receiving waters is to wash cars on grass or another permeable surface to filter dirt and detergents (this practice should be avoided in areas that recharge drinking water supplies). Additionally, citizens should use a sponge and bucket to reduce as much wash water as possible and to allow it to be disposed of down a household drain that is connected to the sanitary sewer or septic system. Finally, low-phosphate detergents should be used to minimize the eutrophic effects of wash water if it enters receiving waters.

2. Lawn, Garden, and Landscape Activities

Lawns are a significant feature of urban landscapes. Estimates of turf and lawn coverage in the United States are as high as 30 million acres, which, if lawns were classified as a crop, would rank as the fifth largest in the country after corn, soybeans, wheat, and hay (Swann and Schueler, 2000). This large area of managed landscape has the potential to contribute to urban runoff pollution due to overfertilization, overwatering, overapplication of pesticides, and direct disposal of lawn clippings, leaves, and trimmings. Also, erosion from bare patches of poorly managed lawns contributes sediment to watercourses, and disposal of lawn clippings in landfills can reduce the capacity of these facilities to handle other types of waste. Public education for homeowners and municipal crews with respect to pest tolerance and proper handling of fertilizers, pesticides, water, and yard waste can greatly reduce the potential for adverse impacts to waters receiving runoff from lawns. Municipalities and watershed managers should develop an outreach campaign that targets homeowners, lawn care businesses, landscapers, and municipal crews. Materials should highlight the following steps to help homeowners and lawn care

professionals maintain healthy, attractive lawns with less maintenance and fewer chemical inputs:

- Lawn conversion.
- Soil building.
- Grass selection.
- Mowing and thatch management.
- Minimal fertilization.
- Weed control and tolerance.
- Pest management.
- Sensible irrigation.

a. Lawn conversion

Grasses are very water-hungry and labor-intensive landscaping plants when compared to ground cover, flowers, shrubs, and trees. Therefore, to reduce the maintenance requirements of a lawn and address problem areas where turf is difficult to grow, property owners could identify areas where turf grass can be replaced with other types of plantings. These areas include lawn edges and places where grass does not grow well, such as frost pockets, exposed areas, dense shade, steep slopes, and wet, boggy areas. Replacement vegetation that is best suited to the local conditions should be chosen to replace turf.

b. Soil building

Lawn owners should analyze their soil every 1 to 3 years to determine its suitability for supporting a lawn and to identify whether additives are needed or adjustments should be made to optimize growing conditions. Soil characteristics that should be measured include soil pH, fertility, compaction, texture, and earthworm content. Soil test kits (for pH and fertility) can be purchased inexpensively at a garden center, or samples can be analyzed by the local cooperative extension service. Soil tests reveal whether fertilizer or lime is needed, helping to avoid overfertilization and loss of nutrients. Soil compaction can be determined by inserting a screwdriver into the soil. If the screwdriver easily penetrates the soil, then aeration is not needed. Soil texture can be determined with a settling test or by squeezing a handful of moistened soil through the fist. If soils prove to be very sandy or very clayey, organic matter should be added. The final test is to count earthworms. The density of earthworms is an indicator of soil texture, and a test that reveals fewer than 10 worms per square foot signifies that the soil may require aeration.

NRCS's Backyard Conservation

USDA's Natural Resources Conservation Service (2000) web site sponsors a Backyard Conservation web site (*www.nhq.nrcs.usda.gov/CCS/Backyard.html*) that presents technical information and management practices to "increase food and shelter for birds and other wildlife, control soil erosion, reduce sediment in waterways, conserve water and improve water quality, inspire a stewardship ethic, and beautify the landscape." The web site includes 10 conservation practice standards, such as composting, mulching, nutrient management, pest management, and terracing, which have been modified to be used in suburban landscapes.

c. Grass selection

Grass seed is available in a wide range of cultivated varieties, so homeowners are able to choose the grass type that grows well in their particular climate, matches site conditions, and is consistent with the property owner's desired level of maintenance. Consideration should be given to seasonal variations in rainfall and temperature. Several grass varieties have been developed that have increased resistance to disease and insect damage, which reduces pesticide use. Some turf varieties have high levels of endophytes, a fungus that does not threaten the grass but eradicates common lawn pests such as billbugs, sod webworms, and aphids. Tall fescue, zoysiagrass, and Bermuda grass tend to be highly resistant to insects (Audubon Society, 2000). Other varieties have been selected to be slow growing, which requires less mowing, fertilizer, and water. Care should be taken to select the species and cultivated variety that is best adapted to the site conditions.

d. Mowing and thatch management

Many property owners strive to maintain a lawn that resembles a golf course. However, mowing a lawn to such a short height increases its susceptibility to drought, sun damage, and weed encroachment; prevents the development of deep roots; inhibits lateral stem growth; and can encourage the overdevelopment of thatch (a straw-like layer between the grass and soil that signifies unhealthy growth conditions and can result from shallow watering, overfertilization, and close mowing). Property owners might need to mow grass more frequently to maintain a minimum healthy height depending on the type of grass planted and the local climate. Property owners should understand that grass grows at different rates throughout the seasons. Therefore, grass should be mowed only as needed. If excessive thatch (which can prevent nutrients and water from reaching grass roots) has developed, the lawn should be dethatched by raking or automated dethatcher and/or sprinkled with compost and aerated.

To prevent insects and weed problems, property owners should mow high, mow frequently, and keep mower blades sharp. Lawns should not be cut shorter than 2 ½ to 3 ½ inches because weeds can grow more easily in short grasses. Grass can be cut lower in the spring and fall to stimulate root growth, but not shorter than 1 ½ inches (Audubon Society, 2000).

e. Minimal fertilization

Based on the results of the soil test described above, a lawn might require additional nutrients to promote or maintain healthy growth. Nutrients can be partly supplied by leaving a moderate amount of fine grass clippings on the lawn after mowing—these clippings can provide nearly half of the required nutrients to the lawn and they hold in moisture, speed decomposition, and relieve the burden of landfills to handle the excess yard waste. Additional nutrients can be supplied with compost or commercially available fertilizers that are of an organic or encapsulated nitrogen type, but they should be applied at or below the rates prescribed on the packaging. Use of compost or organic and encapsulated nitrogen fertilizers reduce the risk of nutrient leaching and have been shown to release nutrients more gradually. Slow release fertilizers are also beneficial for reducing nitrogen losses from soils that are prone to leaching. Organic products offer the additional benefits of increasing soil condition and promoting the growth of desirable soil organisms.

Case Study: Late-Season Fertilization Effects on Turfgrass Growth and Nitrate Leaching and Runoff Losses

A significant portion of the managed landscape in Connecticut and other states on the east coast is covered with turfgrass. Fertilizer is routinely applied to manage turfgrass vigor and quality. Late-season or "fall" fertilization of cool-season turfgrass is a common practice throughout most of the northern United States, which is typically beneficial for turf quality. An appropriate cut-off date for the last fertilization during late-season fertilization has not yet been identified for most regions. Considering the fact that climatic conditions during the fall vary by regions, it is reasonable to vary the last date of fertilizer application of turf accordingly. However, fertilizer recommendations for many northern regions typically recommend a November application or are vague in providing a date for the last application. Applying fertilizers past the date when cool-season turfgrasses become dormant increases the potential of nitrate losses from runoff and leaching.

A two-year study by the University of Connecticut, which is still underway, is seeking to determine an appropriate cut-off date for fall fertilization of turf in southern New England that maintains acceptable turf quality while minimizing nitrate runoff and leaching losses. Applying fertilizers appropriately can help reduce nutrient enrichment of surface water and ground water. The study established a typical home lawn mixture of Kentucky bluegrass, perennial ryegrass, and creeping red fescue (from sod) on plots. The plots were managed with standard lawn care practices and soil monolith lysimeters were placed in each plot to collect percolating soil water from the turf. Runoff plots were also constructed adjacent to and downslope of the lysimeters. The turf is fertilized using a typical schedule of three applications: 1) once in the spring; 2) once in the early summer; and 3) once in the late season. A total nitrogen rate of 3 pounds of nitrogen per 1,000 cubic feet will be split equally across each application.

Timing of fertilizer application is an important consideration. Fertilizer should not be applied when rain is expected. Not only will the rainfall decrease the effectiveness of the fertilizer application, but it will also increase the risk of surface and ground water contamination. Fertilizer should be applied in the season most appropriate for each grass type to ensure that nutrients are fully utilized. Cool season grasses should be fertilized in the fall, whereas warm season grasses should be fertilized frequently and in small doses during the summer. Applying fertilizer at the wrong time might promote the growth of weed species or may increase the plants' water needs. A local cooperative extension service should be consulted about the proper use of fertilizers. State-specific cooperative extension service information is available from the Cooperative State Research, Education, and Extension Service (CSREES) at *www.reeusda.gov* or from *farmboys.com/resources/ext_serv/ext_serv.htm*.

f. Weed control and tolerance

A property owner must decide how many weeds can be tolerated before action is taken to eradicate them. A few weeds will not substantially interrupt the continuity of the turf. The best way to keep weeds at bay is to maintain a healthy, dense lawn that shades the ground surface, preventing weed seedlings from taking root. However, if weeds do take hold, they should be dug or pulled out. If patches of weeds are present, they can be covered for a few days with a black plastic sheet, a technique called solarization. Solarization kills the weeds while leaving the grass intact. If weeds blanket a large enough area, the patch can be covered with clear plastic for several weeks, effectively "cooking" the weeds and their seeds. The bare area left behind after weeding should be reseeded to prevent weeds from growing back. As a last resort, homeowners can use chemical herbicides to spot-treat weeds. A local cooperative extension service should be consulted about the proper use of herbicides. State-specific information regarding cooperative

extension services is available from CSREES at www.reeusda.gov or at farmboys.com/resources/ext_serv/ext_serv.htm.

g. Pest management

Integrated Pest Management (IPM) is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. IPM programs use current, comprehensive information on the life cycles of pests and their interaction with the environment. This information, in combination with available pest control methods, is used to manage pest damage by the most economical means and with the least possible hazard to people, property, and the environment.

IPM is not a single pest control method but a series of pest management evaluations, decisions, and controls. IPM is a sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools. Biological controls involve the use of natural pest enemies to manage pests. Cultural practices include mowing, fertilization, irrigation, aeration, dethatching, and rolling. Physical controls include removal of insects and affected plant material by hand or removal of pests with store-bought traps. Chemical controls involve the use of pesticides to control pests. Municipalities can encourage homeowners to practice IPM and train municipal maintenance crews to use these techniques for public open space.

Effective pest management begins with maintenance of a healthy, vigorous lawn that is naturally disease resistant. Mulching can be used to prevent weeds where turf is absent, fencing can be

Case Study: Target Herbicide Application

Targeted herbicide application, which uses infrared and other technologies, can help locate and control roadside weeds at lower costs than conventional weed control methods (Stidger, 2001). Patchen, Inc., which is located in Ukiah, California, manufactures small sensors that can be used on trucks or other equipment to pinpoint the location of undesirable plants and then target and spray the weed with herbicide. Each sensor views a 12-inch wide area and upon finding weeds, it signals a spray nozzle to deliver a precise amount of herbicide. The unit will spray only on weeds and not on bare ground. Several California Department of Transportation districts have already mounted the sensors onto equipment. According to company reports, a side-mounted strip of sensors at the rear of the vehicle lets the unit target and spray roadside weeds at 10 miles an hour. Sensors can be also used at night when there is less traffic because the sensors have their own light source. Compared to broadcast or manual spot spraying, sensors reduce the quantity of herbicide used and cut overall costs by 50 to 80 percent. Sensors also cut costs by reducing required work hours, because only the driver is needed to apply the herbicide.

Research at North Carolina State University (Burton and Skroch, 1997) developed an herbicide applicator to attach to weed mowers to control roadside vegetation. The unit applies a film of chemical to the weed stem as the mower cuts the plant. Between 70 and 90 percent of the herbicide is absorbed into the plant to prevent future growth. With other methods, as much as 80 to 90 percent of the sprayed chemical misses its target and is wasted.

The Minnesota Department of Transportation tested four innovative herbicide sprayer designs in an effort to reduce costs. According to a research report, all four sprayers saved money when compared to traditional sprayer use. Net annual savings from each of the four sprayers ranged between $23,255 and $65,812.

installed to keep rodents out, and netting can be used to keep birds and insects away from leaves and fruit. Property owners should monitor plants for obvious damage and should check for the presence of pest organisms. It is important to be able to distinguish beneficial insects and arachnids, such as green lacewings, ladybugs, and most spiders, from ones that will damage plants. When damage is detected or when harmful organisms are present, property owners should determine the level of damage the plant is able to tolerate. No action should be taken if the plant can maintain growth and fertility in the presence of these pest organisms. If controls are needed, there is an arsenal of low-impact pest management controls and practices to choose from, including the following:

(1) Visible insects can be removed by hand (with gloves or tweezers) and placed in soapy water or vegetable oil. Alternatively, insects can be sprayed off the plant with water or in some cases vacuumed off of larger plants.

(2) Store-bought traps, such as species-specific, pheromone-based traps or colored sticky cards, can be used.

(3) Sprinkling the ground surface with abrasive diatomaceous earth can prevent infestations by soft-bodied insects and slugs. Slugs also can be trapped in small cups filled with beer that are set in the ground so the slugs can get in easily.

(4) In cases where microscopic parasites, such as bacteria and fungi, are causing damage to plants, the affected plant material can be removed and disposed of. (Pruning equipment should be disinfected with bleach to prevent spreading the disease organism.)

(5) Small mammals and birds can be excluded using fences, netting, tree trunk guards, and, as a last resort, trapping. (In some areas trapping is illegal. Property owners should check local codes if this type of action is desired.)

(6) Property owners can promote beneficial organisms, such as bats, birds, green lacewings, ladybugs, praying mantis, ground beetles, parasitic nematodes, trichogramma wasps, seedhead weevils, and spiders, that prey on detrimental pest species. These desirable organisms can be introduced directly or can be attracted to the area by providing food and/or habitat.

When these lower-impact practices are not enough to remove the pest species, homeowners can use chemical controls. Chemical controls are highly effective but may result in damage to or death of desirable species such as bees. Strong chemical pesticides can contaminate receiving waters, especially when they are applied over large areas or just before a storm. Several less-toxic pesticide alternatives are available to prevent infestations or to halt current infestations, including spraying plants with a solution of dishwashing detergent and water. Garlic and baking soda also have been shown to be effective when applied as an aqueous solution to plants. Other pest control alternatives include insecticidal soap, which destroys pest membranes, *bacillus thuringiensis* (a beneficial bacteria found in compost and other organic soil additives), milky spore (a natural bacteria that kills the grub phases of Japanese beetles), and dormant oil sprays applied when the plants are not growing.

The University of Maryland developed a test for bluegrass, ryegrass, and fine fescue lawns to determine whether pesticide application was necessary. The premise of the test is that each insect has a population level below which spraying does more harm than good. To conduct the test, three sides of a square foot of sod, one inch deep, should be cut back with a flat blade shovel. If fewer than 6 to 10 grubs, 6 to 8 billbugs, 4 to 6 sod webworms, or 15 to 20 chinch bugs are found, the sod should be replaced, the lawn watered thoroughly, and no pesticides need to be applied (Audubon Society, 2000). If more insects are found, then pesticides might be warranted.

If chemical pesticides are used, municipalities should try to select the least toxic, water soluble, and volatile pesticides possible. All selected pesticides should be screened for their potential to harm water resources. Organophosphate pesticides, such as diazinon and chlorpyrifos, are popular because they target a broad range of pests and they are less expensive than newer, less toxic pesticides. Organophosphates rank among the worst killers of wildlife, however, and they often pose the greatest health risk. Synthetic pyrethroids are more selective and typically much less toxic than organophosphates, yet they can harm beneficial insects. When possible, pesticides that pose less risk to human health and the environment should be chosen (Audubon Society, 2000). A list of popular pesticides, along with their uses, their toxicity to humans and wildlife, EPA's toxicity rating, and alternatives to the listed chemicals is available from *The Audubon Guide to Home Pesticides* at *magazine.audubon.org/pdf/pesti_chart.pdf*.

Where necessary, restrictions should be placed on the timing, amount, and areas of application for each pesticide. Before applying any pesticide, the label directions should be read and followed. Pesticides should be applied correctly to minimize drift or runoff and they should not be sprayed near water sources. Application should be avoided during windy conditions or when rain is forecast. Granular applications should be targeted away from impervious surfaces and bodies of water. Equipment should be checked for proper calibration before pesticide application. After pesticides are applied, label directions should be followed to safely dispose of containers. A local cooperative extension service should be consulted about the proper use of pesticides. State-specific information regarding cooperative extension services is available from CSREES at *www.reeusda.gov* or at *farmboys.com/resources/ext_serv/ext_serv.htm*.

Pest management methods can also be altered legislatively. In response to the negative effects of many pesticides, some parts of the country are planning to restrict or prohibit the use of certain hazardous pesticides (Johnson, 1999). The city of Seattle and King County, Washington, intend to stop using pesticides that are deemed most hazardous to control bugs and weeds along roads, in parks, and on other public land. The plan will phase out the use of dozens of hazardous pesticides as the city and county explore less toxic alternatives. Pesticides that will be phased out contain known cancer-causing ingredients, seep quickly into ground water or surface water, or are labeled highly toxic to birds, fish, or other animals. There will be exceptions to the ban on some chemicals, but generally only if there are major health or safety considerations.

Restrictions on the use of certain pest control products were also implemented in California. In 1994 a bill was passed that would restrict the sale and use of copper-containing root killers and copper and tri-butyl tin-containing cooling tower additives (City of Palo Alto, California, Environmental Compliance Division, 1997). These pest control products contribute to the Regional Water Quality Control Plant's (RWQCP's) exceedances of San Francisco Bay

discharge standards. When used, these products are discharged to sanitary sewer systems or to storm drains that flow untreated to creeks and bays. Because cost-effective alternatives for these products are available, the RWQCP and other local wastewater treatment plants have urged restrictions on the three types of chemicals. The state Department of Pesticide Regulation adopted regulations in December of 1995 that made it illegal to sell or use copper-based root control products and tri-butyl tin-containing cooling water additives within the nine San Francisco Bay area counties. These regulations became permanent in November 1996.

Case Study: Arcata Pesticide Use Ordinance

Recently the City of Arcata, in Northern California, created an ordinance that officially eliminated the use of pesticides on all properties owned or managed by the city (CATs, 2000). When city residents became aware of the dangers of pesticides, they demanded change. By 1986, the city council was composed of an anti-pesticide majority and had received so much feedback about the city's pesticide use that it created a citizen's task force to search for nontoxic alternatives. The task force compared the costs of pesticide application and manual vegetation removal and found that increased labor costs were balanced by decreased costs of purchasing, applying, reporting, and storing of the pesticides. The city then conducted small-scale tests to determine the most efficient and cost-effective solutions. Upon receiving the task force recommendations in May of 1986, the City Council consequently declared a moratorium on the use of all pesticides on city properties. Workers gradually became accustomed to the moratorium and now find the use of alternatives routine. Years later, the city decided to establish an ordinance that established successful nontoxic practices as permanent city policy. In February 2000, the City Council unanimously approved the ordinance. Arcata hopes that this ordinance will be a model for other cities with similar health and safety concerns.

h. Sensible irrigation

The natural reaction of grasses to drought stress is to become dormant, halting growth, conserving resources, and turning dry and brown. In spite of this natural drought tolerance mechanism, many property owners strive to maintain lush, green lawns, even in times of dry weather. Watering practices vary from a light sprinkling during dry weather to regular, sometimes excessive automated watering. Underwatering fails to provide water below a few inches of soil, causing grasses to be fragile and shallow-rooted. Overwatering promotes excessive growth and humid, disease-prone conditions that can damage the lawn. The lawn should be watered only when needed and sprinklers should be carefully calibrated to wet the soil to a depth of 6 inches without causing runoff. Additionally, watering should be done early in the morning to prevent excessive evaporation. Determining and controlling the rate, amount, and timing of irrigation will reduce soil erosion, runoff, and fertilizer and pesticide movement. An irrigation system should be designed to have an average application rate that is less than the infiltration capacity of the soil to avoid surface ponding and to maximize water percolation.

3. Commercial Activities

a. Detect and eliminate illicit connections

Illicit connections are defined as "illegal and/or improper connections to storm drainage systems and receiving waters" (Caraco et al., 1998). A discharge of industrial wastewater to a storm sewer is "illicit" because discharges of that type would ordinarily require a permit under NPDES.

Many building owners and operators are unaware that improper connections exist in their facilities. In extreme cases of illicit dumping, legal action is necessary.

Identification of illicit and improper connections is necessary for all sanitary and storm sewer systems, especially in areas where pollutants with unknown sources have been detected in receiving waters. The level and type of industrial activities and the surrounding land uses will affect the methods used to identify illicit connections.

The following are some practices used to prevent, discover, and eliminate illicit connections:

(1) Instituting building and plumbing codes to prevent connections of potentially hazardous pollutant sources to storm drains.

(2) Organizing structures to be inspected for illicit connections by building age, with older buildings identified as priorities. Businesses whose activities have the greatest potential to create sources that could adversely affect water quality and pose human health problems also should be given priority.

(3) Mapping each area to be surveyed and indicating the route of the sewer system and the locations of storm drains on the map. This enables watershed managers to estimate the likely locations of illicit connections.

(4) Surveying individual buildings to discover where connections to the storm drain exist.

(5) Inspecting sewer lines with television equipment to visually identify all physical connections.

(6) Comparing the results of field tests and video inspections with the known connections on the map. Areas with suspected connections should be further investigated.

(7) Instituting mandatory inspections for new development, redevelopment, and remodeling projects.

(8) Removing and testing sediment from catch basins or equivalent structures.

(9) Inspecting questionable connections to determine whether they should be connected to the storm drain system or to the sanitary sewer. Methods of illicit connection identification, such as dye testing, visual inspection, smoke testing, and flow monitoring, are described below.

   (a) *Dye testing*. Flushing fluorometric dye into suspected connections can be useful to identify illicit connections. Once the dye has been introduced into the suspected connection, the water in the collection system is monitored to determine whether a connection is present.

   (b) *Visual inspection*. Remotely guiding television cameras through sewer lines is another way to identify physical connections.

   (c) *Smoke testing*. Smoke testing is another method used to discover illicit connections. Zinc chloride smoke is injected into the sewer line and emerges via vents on connected

buildings or through cracks or leaks in the sewer line. By monitoring and recording where the smoke emerges, crews can identify all connections, legal and illegal, to the sewer system. (Mechanisms on drains should prevent the smoke from entering buildings; however, in some instances, this will occur. It is important to notify the public that the smoke is nontoxic, though it should be avoided as it can cause irritation of the nose and throat for some people.)

(d) *Flow monitoring*. Monitoring increases in storm sewer flows during dry weather can lead investigators to sources of infiltration or flow due to illicit connections.

Rain events can hamper efforts to monitor flows and conduct visual inspections. Smoke and dye testing are more accurate than visual inspection and are the preferred methods for identifying illicit connections.

Illicit discharge detection and elimination programs are designed to prevent contamination of surface and ground water supplies by monitoring, inspection, and removal of these non-storm water discharges, which are illegal if an ordinance has been enacted. These ordinances grant a municipality the authority to inspect properties suspected of releasing contaminated discharges into storm drain systems. Another important factor is the establishment of enforcement actions for those properties found to be in noncompliance or that refuse to allow access to their facilities. EPA (1999), in conjunction with the Center for Watershed Protection, published a model ordinance for illicit discharges on their model ordinances web site (*www.epa.gov/nps/ordinance/discharges.htm*). The model ordinance includes language to address illicit discharges in general as well as illicit connections specifically from industrial sites. Municipalities should modify the language to take into consideration enforcement methods that are appropriate for the local area.

The cost of smoke testing, dye testing, visual inspection, and flow monitoring can be significant and time-consuming. Site-specific factors, such as the level of impervious area, the density and ages of buildings, and land use will determine the level of investigation necessary. Case studies in Michigan have estimated the cost of two full-time field staff and other required support to be between $182,000 and $187,000 annually (Ferguson et al., 1997).

An illicit discharge detection program can be an effective method to reduce the quantity of pollutants related to industrial and commercial activities that enter the storm drain system. For example, the Montgomery County, Maryland, Department of Environmental Protection (MCDEP) has an illicit discharge detection and elimination program, called "Pipe Detectives," that uses volunteer monitoring and community hotlines to identify suspicious discharges (MCDEP, 1997). When discharges are reported, DEP consults maps of surrounding areas and target these areas for additional monitoring to narrow the search for the illicit connection. In one instance, a "milky white" discharge was reported in an area with many small businesses and large apartment buildings. Businesses were sent informational letters advising them of the discharge and requesting their assistance in identifying it by allowing MCDEP to survey the properties. Through this cooperative effort, three illicit connections were detected and removed, including a sink that was used to wash paintbrushes (the source of the milky white discharge).

The Santa Clara Valley (California) Nonpoint Source Control Program published a guide with pollution prevention practices for industrial facilities entitled *Best Management Practices for*

Industrial Storm Water Pollution Control (Duke and Shannon, 1992). The guide presents 21 practices intended to reduce nonpoint source loadings from industrial and commercial activities, including employee and customer training; illicit discharge elimination; waste storage, handling, and disposal; equipment inspection and maintenance; facility design features; and storm water management. The guide presents detailed technical guidance for common pollutants generated by commercial and industrial activities. The Santa Clara Valley Nonpoint Source Control Program has other pollution prevention publications that target specific businesses, such as automotive repair, construction trades and roadwork, landscape/gardening and pool maintenance, mobile cleaners and detailers, and restaurants. For additional information, contact the Nonpoint Source Control Program Information Line at 800-794-2482.

b. Encourage good housekeeping practices at commercial facilities

One of the best and least expensive ways to reduce or eliminate pollutants in runoff is to limit the exposure of materials that can be eroded or dissolved by rainfall and runoff. An inventory of the items on commercial sites that are exposed to rain and runoff provides useful information and a starting point for exposure-reduction activities. To help keep rain from contacting pollutants, businesses should be advised to keep dumpsters and other containers securely closed, store containers under cover, and cover stockpiled materials, such as gravel, wood chips, and building materials, with plastic sheeting. Businesses should be asked to clean up their sites, but not by washing grit and grime into the storm drain system. Instead they should pick up litter, sweep, dispose of sweepings in the garbage (unless they are hazardous and require special disposal), and use absorbent materials such as manufactured absorbent snakes, kitty litter, or sawdust to absorb oils.

c. Provide training and education for employees and customers

Education of employees and customers at commercial sites is key to establishing good pollution prevention practices. Training programs provide information on material handling and spill prevention and response to better prepare employees in case of an emergency. Employees should also be trained on the purpose, operation, and maintenance of pollution prevention management practices. Employees can be continually educated with periodic training courses and with signs reminding workers of good housekeeping practices. Customers should be informed of efforts to reduce waste and pollution using signage or pamphlets so they will be less likely to contribute to pollution problems that are ultimately the responsibility of the business.

d. Devise spill prevention, control, and cleanup plans

The best way to avoid runoff contamination from spilled materials is to prevent the spill from occurring. Careful storage of materials in sound, clearly labeled containers and regular inspection and maintenance of equipment are key practices to prevent spills. Materials stored outdoors should be covered and kept on a paved area to protect them from being mobilized by wind and runoff. If not roofed, the storage area should be designed to drain with a slight slope (approximately 1.5 percent) to an area that will provide treatment prior to disposal. Runoff from other areas should be excluded to reduce the volume of runoff requiring treatment by installing berms, curbs, or diversions on the perimeter of the storage area. Secondary containment should be used when liquids are stored, and runoff or spills from the containment area should be directed to the sanitary sewer where permissible or to an appropriate storage or treatment facility for reuse or disposal.

Business managers should develop and post a set of well-defined procedures for handling spills of any materials that might be exposed to rainfall or runoff. Procedures should cover small, easy-to-handle spills as well as large spills that require employees to contact emergency personnel. The procedures should emphasize that spills must be cleaned up promptly and should specify how each type of material should be handled. The use of water for cleanup should be strongly discouraged. Shop rags should be used for small spills of non-volatile chemicals, and used rags should be sent to a professional cleaning service to prevent them from causing a pollution problem in a landfill or other disposal area. Larger spills should be absorbed with vermiculite, sawdust, kitty litter, or absorbent "snakes." Disposal methods depend on the hazard level of the spilled material. Nonvolatile liquids can be cleaned up with a wet/dry shop vacuum and disposed of with the rest of the facility's waste. Drains or inlets to storm sewers should be plugged during spill remediation to prevent off-site export of pollutants.

e. Conduct an environmental audit

Another approach to pollution prevention at commercial sites is to focus on source reduction, which reduces the amount of waste materials that have the potential to contaminate runoff. A reduction assessment can be performed to evaluate the type and amount of materials currently used, processes conducted, and wastes generated. Such an assessment can provide recommendations for modifying the commercial process to generate less waste, using alternative raw materials to generate nonhazardous wastes, and identifying recycling options to reduce the amount of wastes that require disposal. EPA's Office of Pollution Prevention and Toxics web site (*www.epa.gov/p2/assist/index.htm*) offers technical information and assistance about environmental audits for both businesses and state regulatory agencies (USEPA, 2001a).

f. Practice safe equipment washing and maintenance

It is important when washing and maintaining equipment to adhere to certain pollution prevention measures. When cleaning industrial equipment, in most cases the resulting flow must be discharged as process wastewater to the sanitary sewer and is not allowed in storm drains. When cleaning greasy equipment or trucks, a special cleaning area should be designated and equipment installed to capture, pretreat, and discharge the wash water to the sanitary sewer. In addition, instructional signs that prohibit changing vehicle oil, washing with solvents, and other activities should be posted in non-wash areas. Finally, sumps or drain lines should be installed to collect wash water for treatment and discharge to the sanitary sewer.

Waste materials from vehicle maintenance activities also deserve special attention. Proper storage of materials and proper disposal of waste products is imperative. For example, waste oil, antifreeze, spent solvents, and some other liquids can be recycled. Spent batteries, however, should not be discarded with trash, but must either be disposed of as a hazardous waste or returned to the dealer from whom they were purchased. In addition, when performing maintenance on a vehicle, it should be done in an indoor garage, not in an outdoor parking area.

g. Use care when performing construction, repairs, or remodeling

When repairing, remodeling, or constructing buildings there are several key pollution prevention techniques that can prevent adverse effects on natural systems. Paints should be mixed where spills can be recovered or cleaned easily, and an impermeable ground cloth should be used while painting. Paint buckets and barrels of materials should be stored away from contact with runoff.

During painting cleanup, if a water-based paint was used, brushes and equipment should be cleaned in a sink connected to the sanitary sewer; if oil-based paints were used, they should be stored or recycled and not be disposed of in the sink or storm drain. Spray painting requires a few extra precautions. Temporary scaffolding should be used to hang drop cloths or draperies to shield the user from the wind, to collect overspray, and to minimize the spreading of windblown materials. Users should be aware of air quality restrictions on spray paints that use volatile chemicals and consider water-based spray paints to minimize adverse effects on air quality.

Sand blasting can be controlled to keep particles off of paved surfaces and out of storm drains by placing a tarp or ground cloth beneath the work to capture the blasting medium, protect the work area from wind, and capture airborne particles.

4. Proper Disposal of Pet Waste

Pet owners have several options for properly managing pet waste. Collecting the waste and flushing it down the toilet, where it can be treated by a sewage treatment facility or septic tank, is the preferred method. Small quantities can also be buried in the yard, where the waste can decompose slowly. When buried, the waste should be at least 5 inches below the ground surface and away from waterbodies and vegetable gardens. In public areas, the waste can be sealed in a plastic bag and thrown in the trash, which is legal in most areas (Water Quality Consortium, 1999).

Many communities implement pet waste management programs by posting signs in parks or other areas frequented by pet owners, sending mailings, and making public service announcements. Many communities have "pooper scooper" ordinances that govern pet waste cleanup. Some of these laws specifically require anyone who takes an animal off his or her property to carry a bag, shovel, or scoop. Any waste left by the animal must be cleaned up immediately (Hill and Johnson, 1994). In addition to postings, many communities have also installed "pet waste stations" in popular dog parks. These stations contain waste receptacles as well as a supply of waste collection bags, scoops, and shovels.

Los Angeles County Pet Waste Program

The Los Angeles County Department of Public Works Environmental Programs Division developed a program to control pet waste (Lehner et al., 1999). By profiling various groups of pet owners, the division identified the best targets for reducing coastal pollution. The program included a multimedia campaign to educate new and existing pet owners about the water quality impacts of pet waste. The program also distributed cleanup kits to owners and installed plastic bag dispensers in parks. The division established partnerships with local pet stores and pet supply companies to promote the program.

5. Trash

When developing control strategies for trash, the source of the trash should be considered to most effectively implement a control structure designed to target the most prevalent types of trash. Second, the costs for each control strategy should be evaluated, and a budget should be developed that takes into consideration the services and facilities that are already available and can be utilized at the lowest cost. Third, regular cleaning and maintenance of storm water

control infrastructure is necessary to prevent the accumulation of trash at control structures from becoming a hazard. Finally, it is important to understand that control strategies should not just transport trash to another waterbody but should reduce the quantity of trash entering waterbodies.

There are two methods of trash control: source controls and structural controls. There are four source control types: community education, improved infrastructure, waste reduction, and cleanup campaigns. Community education, such as informing citizens about options for recycling and waste disposal and educating them about the consequences of littering, can instill a sense of responsibility in citizens to maintain a clean environment. Improved infrastructure can include optimizing the location, number, and size of trash receptacles, recycling bins, and cigarette butt receptacles based on expected need. Waste reduction includes encouraging the purchase of products with less disposable packaging and encouraging manufacturers to reduce the amount of packaging they use. Finally, cleanup campaigns are an effective way to reduce trash. Municipal projects such as street sweeping, receptacle servicing, and cleanup crews along roadsides can also be effective in preventing trash from accumulating and entering waterways.

Structural controls include physical filtering structures and continuous deflection separation. Physical filtering structures concentrate diffuse, floating debris and trash and prevent it from traveling downstream. Some examples of physical filtering structures are trash racks, mesh nets, bar screens, and trash booms. Continuous deflection separation targets inputs of trash from storm flows during and after heavy precipitation events and involves physical separation of solids and floatables from water in runoff detention structures by increasing the settling time of trash and particles.

The costs for trash controls vary depending on the method employed. For example, the cost of a community education program or a plan to increase the number of trash receptacles can be minimal, depending on the quality of existing programs and extent of existing infrastructure. On the other hand, a structural control strategy can be quite costly. Physical filtering structures, including trash racks, bar screens, and silt traps, can range from $250,000 to $905,000, not including maintenance. A large-scale continuous deflection separation device for urban runoff can cost as much as $3 million (capital cost only).

Street sweeping is a common practice in many communities. Street sweeping programs can be optimized to significantly reduce trash and other pollutants on urban streets. Study results suggest that reductions of up to 80 percent in annual TSS and associated pollutants could be achieved by using bimonthly to weekly sweepings. Sweeping frequency would vary with patterns of precipitation, sediment accumulation, and resuspension. The effectiveness of any street sweeping operation will vary with land use, precipitation, and the accumulation dynamics of contaminated sediments (Sutherland and Jelen, 1997).

Sweeping technology can have a profound effect on sweeping results. Previously, sweepers were unable to pickup very fine sediments that can be highly contaminated. Today, street sweeping has proven to be an effective management practice for reducing pollutant loads to waterways. High-efficiency pavement sweepers are thought to be very efficient at picking up a large portion of the very fine particulate material that accumulates on street surfaces. A high-efficiency sweeper uses strong vacuums and the mechanical action of brooms, combined with an air filtration system that returns only clean air to the atmosphere. Minton et al. (1998) found that

simulated results for high-efficiency sweepers in residential areas reduced annual TSS washoff by 51 to 87 percent. Other sweepers reduced annual TSS in these same areas by up to 71 percent. When sweeping in major arterials with high pollutant loads, simulated results indicated that annual TSS washoff was reduced by 49 to 85 percent. Other tested sweepers reduced annual TSS washoff in major arterials by up to 24 percent (Minton et al., 1998).

High-efficiency sweepers were also compared to the efficiency of wet vaults (Sutherland et al., 1998). Simulated results indicate that high-efficiency sweepers removed 40 to 75 percent of annual TSS, while water vaults removed 75 to 91 percent. All removal efficiency ranges depended on sweeping frequency.

The projected water quality benefits of high-efficiency street sweeping are based on modeling. Because the technology has not been field verified and there is currently no end-of-the-pipe water quality data to verify the modeling results, high-efficiency sweeping is not widely used at this time (Minton et al., 1998).

6. Nonpoint Source Pollution Education for Citizens

Many citizens know very little about nonpoint source pollution. Schueler and Swann (2000a) reported that an estimated 41 percent of the population had any idea of what the term "watershed" means, and only 22 percent understood that runoff is the most common source of pollution to streams, rivers, and oceans. Therefore, watershed and nonpoint source education for citizens is important to increase awareness about the environmental consequences of everyday actions. A survey of the effectiveness of outreach programs showed that media campaigns and intensive training of target audiences are the most effective ways to effect change in citizen behavior (up to 10 percent change in behavior in target populations). Specifically, TV ads and programs, newspaper ads, radio ads, and direct mail campaigns were shown to be the most influential and memorable messages to the public.

Schueler and Swann (2000a) recommend the following techniques to effectively market a watershed message:

(1) Present a simple, direct watershed message, repeat it frequently, use multiple types of media, and emphasize the connection between the message and a local waterbody.

(2) Develop an increased awareness of the connection between yards, streets, storms, and streams.

(3) Pool resources with other local or regional organizations to expand the budget for the campaign.

(4) Use cable network and public television channels for commercials and targeted TV programs to more effectively reach target audiences.

(5) Focus the campaign on one or more target audiences. In general, men between the ages of 35 and 55 with relatively high income and education levels are most likely to engage in polluting activities. However, a survey of watershed demographics and problem pollutants should be conducted to better identify target populations.

(6) Keep the message simple and humorous and develop durable, attractive, nontechnical outreach materials.

(7) Educate and partner with private sector companies such as septic tank cleaners, commercial car washes, and oil change franchises.

a. Use multilingual nonpoint source messages

Many communities are ethnically and culturally diverse, and a portion of the population speaks languages other than English. The messages contained in signs, brochures, advertisements, newsletters, and other outreach materials that are printed only in English are mostly lost on these groups. For example, in areas such as southern Florida and southern California, where a large proportion of the population consists of Spanish-speaking immigrants, it is important to reach out to non-English speaking residents and inform them about storm water pollution issues and the importance of clean water, because their activities can generate a substantial amount of pollution. This type of expanded outreach program is not limited to these areas. Census 2000 figures show increasing minority populations in urban centers and suburbs such as Washington, DC (Fernandez, 2001; Cohn and Witt, 2001), and New York (Cohn, 2001), among others.

Outreach materials can be printed in multiple languages based on the demographics of a community. The North Central Texas Council of Governments (NCTCOG), as part of their pollution prevention and public awareness campaign, printed articles, press releases, brochures, flyers, and bill stuffers in both English and Spanish (NCTCOG ,2000). The University of Texas at Austin designed and installed storm drain stencils in both English and Spanish (University of Texas at Austin, 1997).

b. Use classroom education to deliver nonpoint source messages

Providing nonpoint source education to children through schools exposes the educational message not only to students but to their parents as well, because children often take home what they learn. Watershed managers have partnered with educators and experts to develop storm water-related curricula for the classroom. Fortunately, these lessons need not be elaborate or expensive to be effective.

An example of this type of education is the Children's Water Festival in Albuquerque, New Mexico. Several hundred fourth-grade students from schools in the area engaged in hands-on learning activities about water science, history, geography, and drama. The Albuquerque-based Ciudad Soil and Water Conservation District use their "Rolling River" educational model to show how all the components of a watershed are connected and how changes in one part affect others. Students created a mini-river, purified water from the Rio Grande, and built aquifers from edible ingredients. They also used a computer model to make projections of water use in the future and a ground water model to see how water moves underground. Students analyzed water samples and played the role of algae, fish, and raptors to understand how toxins can travel through the food chain. They created wetlands, simulated flood and drought situations, changed the infrastructure, and then observed the effects of their manipulations.

Case Study: Delaware Department of Natural Resources and Environmental Control's Whole Basin Management Strategy

The Delaware Department of Natural Resources and Environmental Control's (DNREC) Whole Basin Management strategy focuses on protecting Delaware's environment by managing it by drainage basin. The strategy uses the state's four major drainage basins (the Piedmont, Chesapeake Bay, Delaware Bay and Estuary, and Inland Bays/Atlantic Ocean Basins) as the chief management units. Whole Basin Management involves a phased approach to assessing the health of the targeted basin and developing an implementation plan to address its environmental problems. The Inland Bays Environmental Profile offers residents a list of ways to contribute to improving the Inland Bays/Atlantic Ocean Basin. Among the recommended activities are several pollution prevention-related activities. Examples of activities recommended in the profile include (DNREC, no date):

Reducing Household Hazardous Waste

- Use non-phosphate laundry detergents or purchase nontoxic cleaning products.
- Read and follow directions on labels carefully.
- Use latex paint instead of oil-based paint and stains and finishes derived from natural sources if possible.
- Use fabric softener sheets rather than liquids (they have a lower metals count), or add one cup vinegar or a quarter cup of baking soda to the final rinse.
- Know how to identify (labeled "danger," "warning," or "caution") and safely dispose of hazardous products.

Maintaining a Healthy Lawn and Garden

- Perform soil tests every 3-4 weeks to determine the amount of nutrients necessary for a healthy lawn. Contact your local soil conservation district for more information and test kits.
- Lawns should be 2-4 inches high. Cutting too short or too frequently weakens grass and cultivates weeds.
- Leave grass clippings on the lawn to serve as a natural fertilizer or compost them.
- Use pesticides sparingly and read and follow directions carefully. Try to use natural alternatives. Never use pesticides if rain is forecast to avoid runoff into a local stream or storm drain.
- Do not overwater lawns or gardens to prevent chemicals from leaching into ground water.

Recycle paper, plastic, cans, glass, cardboard, motor oil, oil filters, and batteries

Build a Compost Pile

- Select a flat, well-drained spot that gets full sun. Try to build the pile in the middle of the garden.
- Construct a compost bin out of lumber, bricks, concrete blocks, or wire. Make sure the bin has air openings.
- Feed the pile, mixing coarse and fine materials in 6- to 8-inch layers. The bottom layer should contain twigs, chopped cornstalks, or other coarse material. Next add a layer high in nitrogen such as grass clippings or manure. Top with soil and repeat the process. Sprinkle the pile with water.
- Mix the layers well and shape so the center is lower than the sides to help water flow into the pile. Turn the pile once a month and remoisten the material as it is turned.

Keep Septic Systems Functioning Properly

- Keep all toxic and hazardous materials out of septic systems and minimize the solids and liquid loads.
- Avoid dumping grease and fats down kitchen drains. Collect grease in a container beside the sink.
- Have a septic tank pumped by a certified contractor every 3 years.

Follow Bay-Friendly Boating Practices

- Avoid discharging sewage directly into the water, and do not litter.
- Clean fish at designated areas and dispose of waste in proper containers.
- Avoid over-fueling, and perform boat maintenance out of the water if possible.

Additional pollution prevention activities are available from the Inland Bays Environmental Profile, which is available on DNREC's web site at *www.dnrec.state.de.us*.

Information Resources

Appropriate Technology Transfer in Rural Areas (ATTRA) published the guidance *Integrated Pest Management: Fundamentals of Sustainable Agriculture*, which provides a basic understanding of IPM for individuals interested in agriculture at all levels. It incorporates the steps that need to be taken prior to IPM implementation, the tools used, and some ideas about future trends for IPM. The ATTRA publication is available at *www.attra.org/attra_pub/ipm.html* (Dufour and Bachmann, 1998).

The city of Seattle's ProIPM (Seattle Public Utilities, 2000) is the Green Gardening Program's series of IPM fact sheets for landscaping professionals. The fact sheets were designed to assist landscapers in the field and when explaining the IPM approach to clients. Each fact sheet provides essential facts about various northwestern United States pest or disease problems, including information regarding pest identification, life cycle information, monitoring, damage threshold, and treatments. The fact sheets are available for download at *www.cityofseattle.net/util/proipm/default.htm* or by calling the Green Gardening Program at 206-547-7561. The ProIPM web site also provides information about proper disposal methods for pesticide products.

The U.S. Air Force's PRO-ACT program is an environmental research service and information exchange clearinghouse (PRO-ACT, 2000). PRO-ACT's *Integrated Pest Management Fact Sheet* provides information regarding IPM policy and guidance, typical components of an IPM program, control techniques available to pest managers, and management practices that can be implemented in an IPM program. The fact sheet is available at *www.afcee.brooks.af.mil/pro_act/fact/jun00a.asp*. PRO-ACT may be contacted by phone at 800-233-4356 or by e-mail at pro-act@hqafcee.brooks.af.mil.

The National IPM Network (NIPMN, no date) is an evolving and cooperating group of universities, government agencies, and other organizations for providing up-to-date, accurate pest management information to growers, extension members, consultants, regulatory personnel, and the public. NIPMN's web site can be accessed at *plantprotection.org/nipmn/index.htm*.

NRCS (no date) has prepared a backyard conservation tip sheet that provides the public with information on pest management. The tip sheet helps readers to identify the problem, to know what to look for, and to control various types of pests with mechanical, physical, biological, and chemical control strategies. The NRCS tip sheet is available at www.nrcs.usda.gov/feature/backyard/pdf/PestMgt.pdf.

The International Turf Producers Foundation (ITPF, no date) recently published *Water Right: Conserving Our Water, Preserving Our Environment*. The publication provides information about a variety of water topics, including water use and conservation, environmental and economic benefits of responsible landscape management, and landscape water conservation techniques. The document is available for download at *www.turfgrasssod.org/waterright.html* or can be obtained by contacting ITPF at 1855 Hicks Road, Suite C, Rolling Meadows, Illinois, 60008; 847-705-9898 or 800-405-8873.

Audubon Magazine published *The Audubon Guide to Home Pesticides* in 2000. This guide provides homeowners with a list of popular pesticides, along with their typical uses, their toxicity

to humans and wildlife, EPA's toxicity rating, and alternatives for each of the chemicals. The guide is available for download at magazine.audubon.org/pdf/pesti_chart.pdf.

The Pest Management Branch of the California Department of Pesticide Regulation published *Suppliers of Beneficial Organisms in North America*. The publication lists 143 commercial suppliers of 130 beneficial organisms that are used for biological control. Suppliers are located in Canada, Mexico, and the United States. The booklet is available for download at www.cdpr.ca.gov/docs/ipminov/bensuppl.htm.

The EXtension TOXicology NETwork (EXTOXNET) is a joint effort of the University of California at Davis, Oregon State University, Michigan State University, Cornell University, and the University of Idaho. EXTOXNET provides a variety of information about pesticides, including discussions of toxicological issues of concern; toxicology newsletters, fact sheets, and information briefs; pesticide information profiles; and other resources for toxicology information. The network can be accessed at ace.orst.edu/info/extoxnet.

The National Pesticide Telecommunication Network is a cooperative effort of Oregon State University and the U.S. Environmental Protection Agency. The network is a source of chemical, health, and environmental information about more than 600 pesticide active ingredients incorporated into at least 50,000 different products registered for use in the U.S. since 1947. The toll-free telephone service (800-858-7378) provides information about pesticide products, recognition and management of pesticide poisoning, toxicology, and environmental chemistry to any caller in the United States, Puerto Rico, or the Virgin Islands.

Nonpoint Education for Municipal Officials (NEMO) is an educational program created by the University of Connecticut for local land use decision makers that addresses the relationship between land use and natural resource protection, particularly water resources. NEMO is an award-winning program that uses remote sensing, geographic information systems, and Internet technologies. The NEMO model is being adapted around the country, and NEMO projects are being planned and implemented by various agencies and organizations. This nationwide group, under the leadership and coordination of the University of Connecticut NEMO Project, is called the National NEMO Network. Additional information about NEMO is available at nemo.uconn.edu.

Organic Gardening magazine and web site (www.organicgardening.com) provide information about organic pest control and help users find soil-testing labs in their area.

Riversides is a Canadian nonprofit organization that promotes source control and nonpoint source pollution prevention strategies. An important component of the Riversides web site is H_2infO: The Water Information Network, which provides information about current campaigns, resources, and services offered by the network; listservers; and links to agencies, associations, and non-governmental organizations. The H_2infO web site can be accessed at www.riversides.org/newwin/win.html. Also, H_2infO can be contacted at 590 Jarvis Street, Suite 200, Toronto, Ontario, Canada, M4Y 2J4; phone 416-392-1757; fax 416-960-9944; e-mail input@H2infO.org.

EPA's Biopesticide website provides users with specific information about biopesticides, including fact sheets, decision documents, product lists, labels, company lists, study reviews, bibliographies, regulatory information, and federal register notices. The web site can be accessed at *www.epa.gov/pesticides/biopesticides*.

EPA (1995) published the *Citizen's Guide to Pest Control and Pesticide Safety*, which provides users with important information about pesticides, including steps to control pests in and around the home; alternatives to chemical pesticides; methods for choosing, using, storing, and disposing of pesticides; how to reduce exposure when others use pesticides; how to choose a pest control company; and what to do if someone is poisoned by a pesticide. The guide is available at *www.epa.gov/oppfead1/Publications/Cit_Guide/citguide.pdf*.

EPA (1999) published *Education Projects in the Office of Water: A How-to Guide for Developing Environmental Education Projects*. The document provides a road map for creating quality environmental education projects and outlines EPA's procedural guidelines for producing a product or supporting related projects already in existence. It also lists publications, contacts, and references, including web sites, training opportunities, and available materials, that provide the reader with further detail and insight into the process of developing effective environmental education pieces. A list of agencies and organizations that have water-related environmental education programs and projects is provided in an appendix. The publication is available from EPA's National Service Center for Environmental Publications web site at *www.epa.gov/ncepihom*. It can also be ordered by phone, fax, or mail from USEPA/NSCEP, P.O. Box 42419, Cincinnati, Ohio 45242-2419; toll-free 800-490-9198; fax 513-489-8695.

The Commonwealth of Kentucky published *Turfgrass: Best Management Practices for Protection of Water Resources* (USEPA, 2001b). The manual provides information and guidance on turfgrass management practices that decrease adverse effects on water resources. Information about the manual, along with a list of commonly used best management practices for turf management, is available at *www.epa.gov/region4/water/nps/projects/ky94_2.htm*.

The Council of State Governments (1999) published *Getting in Step: A Guide to Effective Outreach in Your Watershed*. The guide presents a step-by-step approach for developing and implementing an effective watershed outreach plan. *Getting in Step* is available for download in PDF format at *www.epa.gov/owow/watershed/outreach/documents/getnstep.pdf* or by calling Books on Demand (800-521-3042).

References

Audubon Society. 2000. Ten commandments for a healthy yard. *Audubon Magazine* May-June. magazine.audubon.org/pdf/pesti_tips.pdf. Accessed August 13, 2001.

Barth, C.A. 1995. Toward a low input lawn. *Watershed Protection Techniques* 2(1):254–264.

Burton, J., W. Skroch, and T. Lucas. 1997. *Scientists Devise New, Safer Way to Apply Roadside Herbicides*. www2.ncsu.edu/ncsu/univ_relations/news_services/press_releases/97_09/293.htm. Last updated September 5, 1997. Accessed October 16, 2001.

Californians for Alternatives to Toxics (CATs). 2000. *Arcata Pesticide Ordinance*. Californians for Alternatives to Toxics. www.alternatives2toxics.org/arcata_ord.htm. Accessed August 2, 2001. Last updated Spring 2000.

Caraco, D., R. Claytor, P. Hinkle, H.Y. Kwon, T. Schueler, C. Swann, S. Vysotsky, and J. Zielinski. 1998. *Rapid Watershed Planning Handbook.* Center for Watershed Protection, Ellicott City, MD.

City of Palo Alto, California, Environmental Compliance Division. 1997. *Urban Pesticide Restrictions for Water Quality Protection*. www.city.palo_alto.ca.us/cleanbay/pdf/urban.pdf. Accessed August 1, 2001.

Cohn, D. 2001, March 16. Immigration fueling big U.S. cities. *The Washington Post*, p. A1.

Cohn, D., and A. Witt. 2001, March 20. Minorities fuel growth in Md. suburbs. *The Washington Post*, p. A1.

Council of State Governments. 1999. *Getting in Step: A Guide to Effective Outreach in Your Watershed*. The Council of State Governments, Lexington, KY.

Delaware Department of Natural Resources and Environmental Control (DNREC). No date. *Whole Basin Management, Inland Bays Environmental Profile: An Environmental Assessment of Southeastern Delaware*. Delaware Department of Natural Resources and Environmental Control, Dover, DE.

Dufour, R., and J. Bachmann. 1998. *Integrated Pest Management: Fundamentals of Sustainable Agriculture*. Appropriate Technology Transfer for Rural Areas (ATTRA), Fayetteville, AR. www.attra.org/attra_pub/ipm.html. Accessed July 31, 2001.

Duke, L.D., and J.A. Shannon. 1992. *Best Management Practices for Industrial Storm Water Pollution Control*. Santa Clara Valley Nonpoint Source Pollution Control Program, San Jose, CA.

Earth's 911. 2000. *Household Hazardous Waste*. www.earths911.com/states/recycling/hhw/default.asp. Accessed June 26, 2000.

Environmental Defense Fund. 2000. *Lawns, Gardens, and the Environment*. www.edf.org/Want2Help/d_lawn.html. Accessed June 27, 2000.

Ferguson, T., R. Gignac, M. Stoffan, A. Ibrahim, and H. Aldrich. 1997. *Rouge River National Wet Weather Demonstration Project*. Wayne County, Michigan, Department of the Environment, Detroit, MI.

Fernandez, M. 2001, April 5. City underwent major racial shifts in '90s, census shows. *The Washington Post*, p. D3.

Hill, J.A., and D. Johnson. 1994. *Pet Waste and Water Quality.* clean_water.uwex.edu/pubs/sheets/lopet.pdf. Accessed January 25, 2002.

International Turf Producers Foundation. No date. *Water Right: Conserving Our Water, Preserving Our Environment.* International Turf Producers Foundation, Rolling Meadows, IL.

Jenkins, V.S. 1994. *The Lawn—A History of An American Obsession*. Smithsonian Institution Press, Washington, DC.

Johnson, T. 1999. City, county to reduce their pesticide use: Most-hazardous poisons will be largely avoided. *Seattle Post-Intelligencer*. seattlep_i.nwsource.com/local/pest06.shtml. Last updated October 6, 1999. Accessed January 22, 2002.

Kopel, D. 1998. *Household Hazardous Waste*. i2i.org/Publications/IP/Environment/enhhw.htm. Accessed January 25, 2002.

Lehner, P.H., G.P. Aponte Clarke, D.M. Cameron, and A.G. Frank. 1999. *Stormwater Strategies: Community Responses to Runoff Pollution*. Natural Resources Defense Council, New York, NY.

Minton, G.R., B. Lief, and R Sutherland. 1998. High efficiency sweeping or "clean a street, save a salmon!" www.schwarze.com/sweepers/ev/mintonvol4No4.html. Accessed August 8, 2001.

Montgomery County Department of Environmental Protection (MCDEP). 1997. *Montgomery County NPDES Municipal Separate Storm Sewer System Annual Report*. MS-MO-95-006. Montgomery County Department of Environmental Protection, Water Quality Advisory Group, Rockville, MD.

Minnesota Pollution Control Agency (MPCA). 2002. *Household Hazardous Waste.* www.pca.state.mn.us/waste/hhw.html#guide. Last updated January 23, 2002. Accessed January 25, 2002.

National Integrated Pest Management Network (NIPMN). No date. *National Integrated Pest Management Network*. plantprotection.org/nipmn/index.html. Last updated August 15, 2001. Accessed January 22, 2002.

Natural Resources Conservation Service (NRCS). No date. *Backyard Conservation Tip Sheet: Pest Management*. U.S. www.nrcs.usda.gov/feature/backyard/pdf/PestMgt.pdf. Accessed August 1, 2001.

North Central Texas Council of Governments (NCTCOG). 2000. *Overview of the Regional Storm Water Program*. www.nctcog.dst.tx.us/envir/wq/inetstw.html. Last updated May 30, 2000. Accessed August 20, 2001.

Northern Virginia Soil and Water Conservation District. 2000. Lake Barcroft WID Sweeps Up. *Conservation Currents* 27 (May/June).

PRO-ACT. 2000. *Integrated Pest Management Fact Sheet*. www.afcee.brooks.af.mil/pro_act/fact/jun00a.asp. Accessed July 31, 2001.

Roberts, E., and B. Roberts. 1989. *Lawn and Sports Turf Benefits*. The Lawn Institute, Pleasant Hill, TN.

Santa Clara Valley Nonpoint Source Pollution Control Program. 1992. *Best Management Practices for Automotive_Related Industries*. Santa Clara Valley Nonpoint Source Pollution Control Program, San Jose, CA.

Schueler, T., and C. Swann. 2000a. On watershed education. *Watershed Protection Techniques* 3(3):680–686.

Schueler, T., and C. Swann. 2000b. Understanding watershed behavior. *Watershed Protection Techniques* 3(3):671–679.

Seattle (Washington) Public Utilities. 2000. *Integrated Pest Management*. www.cityofseattle.net/util/proipm/default.htm. Last updated August 3, 2000. Accessed July 31, 2001.

Stidger, R.W. 2001. Vegetation management: sprayer designs target herbicide application, cut costs. *Better Roads* May:26–30.

Sutherland, R.C., and S.L. Jelen. 1997. Contrary to conventional wisdom, street sweeping can be an effective BMP. In *Advances in Modeling the Management of Stormwater Impacts*, ed. W. James, pp. 179–190. Computational Hydraulics International, Guelph, ON.

Sutherland, R.C., S.L. Jelen, and G. Minton. 1998. High efficiency sweeping as an alternative to the use of wet vaults for stormwater treatment. In *Advances in Modeling the Management of Stormwater Impacts*, ed. W. James, pp. 351–372. Computational Hydraulics International, Guelph, ON.

Tacoma-Pierce County, Washington, Health Department. No date. *Household Hazardous Wastes: Less Toxic Alternatives for Cleaning*. www.tpchd.org/sourceprotection/alter.html. Accessed January 22, 2002.

University of Texas at Austin. 1997. *NPDES Storm Water Management Program*. www.utexas.edu/business/oehs/water/swmp.html. Last updated June 12, 2000. Accessed August 20, 2001.

U.S. Environmental Protection Agency (USEPA). 1999. *Model Ordinances to Protect Local Resources: Illicit Discharges.* www.epa.gov/nps/ordinance/discharges.htm. Last updated October 27, 1999. Accessed June 30, 2000.

U.S. Environmental Protection Agency (USEPA). 2001a. *Pollution Prevention Technical Assistance*. www.epa.gov/p2/assist/index.htm. Last updated November 23, 2001. Accessed April 8, 2002.

U.S. Environmental Protection Agency (USEPA). 2001b. *Turfgrass: Best Management Practices for Protection of Water Resources*. www.epa.gov/region4/water/nps/projects/ky94-2.htm. Last updated May 21, 2001. Accessed January 22, 2002.

Water Quality Consortium. 1998. *Surface Water Quality: What's the Problem with Pet Waste?* www.ci.seattle.wa.us/util/surfacewater/bmp/petwaste.htm. Last updated November 18, 1998. Accessed April 5, 2001.

This page was intentionally left blank